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This report identifies general supplies and equipment according to functional use. Discusses equipment items in the categories of food and food preparation; fuels and servicing units; shelters; general and special purpose clothing and equipment; heating, cooling and ventilating equipment; photographic, printing and optical equipment; and miscellaneous support equipment. Discusses safety considerations, experimental design, instrumentation techniques, statistical techniques, and data reduction. Keywords:

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-100
*Test Operations Procedure 1-1-045 — 30 January 1989
AD No.

GENERAL SUPPLIES AND EQUIPMENT TESTING

1. SCOPE. This TOP introduces Volume 10 of test operations procedures. It identifies equipment items in the following categories: food and food preparation; fuels and servicing units; shelters; general and special purpose clothing and equipment; heating, cooling and ventilating equipment; photographic, printing and optical equipment; and miscellaneous support equipment. It also identifies some of the test considerations to be addressed during the life cycle of general supplies and equipment. Policies and documents governing testing are also discussed.

Volume 10 covers the testing of general supplies and equipment used by the Army. These can be grouped according to the principal functions they perform:

a. Food and food preparation. These are items of ration and means of food preparation for troop use. This category includes the following:

(1) Individual field mess equipment.

(2) Baking and roasting ovens.

(3) Field kitchens and cooking equipment.

(4) Combat rations.

(5) Complete rations.

(6) Individual food items.

*This TOP supersedes TOP 1-1-045 dated 17 March 1972.

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(7) Preparation methods and equipment for food service.

b. Fuels and servicing units. These items consist of military fuels, oils, additives for converting fuels to flame warfare use, and vehicle servicing and lubrication units. The following items are included:

(1) Diesel, MOGAS, aviation, and turbine fuels.

(2) Fuel thickeners, flame throwers.

(3) Lubrication and servicing equipment.

c. Shelters. This equipment is used to provide military personnel and equipment protective shelter under varying environmental conditions. This category includes the following:

(1) Prefabricated buildings.

(2) Tents and shelters.

(3) Foamed-in-place shelters.

(4) Air-inflated or supported structures.

(5) Expandable and contained structures.

(6) Aircraft maintenance shelters.

d. General and special purpose clothing. These items clothe and protect military personnel engaged in combat activities and special phases thereof. This category includes the following items:

(1) Combat uniforms, helmets, and boots.

(2) Protective equipment, masks, gloves, and liners.

(3) Head and body armor.

(4) Aviation and armored vehicle crewmen uniforms.

(5) Foul weather gear.

(6) Diving suits and masks.

(7) LASER safety goggles.

e. General and special purpose equipment. Such equipment items are many and varied. They are used to support military personnel and units and the tactical field operations in which they are engaged. This category includes the following:

(1) Individual load-carrying devices.

(2) Sleeping gear.

(3) Fire extinguishers and fire-fighting equipment.

(4) Boats and waterway equipment.

(5) Maintenance and special-purpose repair shops.

(6) Survival and life-saving equipment.

f. Heating, cooling, and ventilating equipment. This equipment provides body comfort for military personnel and controlled environments for operation of specialized equipment. The following items are included:

(1) Ducted and non-ducted heaters.

(2) Refrigeration and air-conditioning equipment.

(3) Fans and blowers.

(4) Dehumidifiers.

(5) Boilers and furnaces.

g. Photographic, printing, and optical equipment. This specialized equipment assists military personnel and units in performing tactical field operations. The following items are included:

(1) Binoculars, telescopes, and optical devices.

(2) Metascopes and image-intensification devices.

(3) Theodolites and surveying instruments.

(4) Cameras, photographic printers and equipment.

(5) Projection equipment.

(6) Stereoscopic devices.

(7) Field printing equipment.

h. Miscellaneous support equipment. A variety of equipment is required to support logistic and service functions of military units and personnel. Some of these are:

(1) Containers and pallets.

(2) Ice-making machinery.

(3) SCUBA diving equipment.

(4) Vector-control equipment.

(5) Remains pouches and identification systems.

(6) Packaging and preservation equipment.

(7) Air drop support equipment.

(8) Drafting and mapping equipment.

2. OVERALL TEST PHILOSOPHY. General equipment items may be subjected to any of the tests described in AR 70-10[1]* and AR 700-86.[2] Tests primarily germane to commodities of TOP Volume 10 are technical and user types. A distinction must be made between programmatic testing and testing considerations. Programmatic testing is the name given to the test phase in relation to the type of decision to be made. Basically, there is technical testing and user/customer testing.

a. Technical tests (TT) are conducted by/under the supervision of an independent test activity, not a part of the developing agency concerned, in accordance with the controlled conditions and criteria established in a test plan. The purpose of technical tests is to assess the technical performance and safety characteristics of an item/system and its associated system support package (SSP) as described in requirements documents and as indicated by the particular design. Technical tests generally require instrumentation and measurements performed by engineers, technicians, or soldier operator-maintainer test and evaluation (SOMTE) personnel. (Refer to AR 700-127[3] for SSP definition and test objectives.) This determination includes measuring the inherent mechanical, electrical, or other physical and chemical property or technical characteristic, and may use data previously generated during engineer design tests (EDT). The TT is characterized by controlled conditions and the elimination of human judgment error so far as possible, through the use of environmental chambers; physical measurement techniques; controlled laboratory, shop, and field trials; statistical methodology; and use of personnel trained in the engineering or scientific fields. The TT provides data for use in further development as required, and for determinations of the safety, technical and logistic supportability of the item or system for the operational test.

b. User tests (UT) are conducted with troops representative of those who will operate the equipment. The materiel being tested is operated under simulated tactical conditions or conditions similar to those expected during intended operational use. The purpose of the UT is to determine whether the materiel is suitable for its intended use by measuring how well the materiel meets performance standards established in the requirements documents, and testing/assessing the training and system support packages. The UT includes a tactical unit equipped with the materiel during a controlled field exercise to provide data on the overall item/unit effectiveness or military worth as input to the evaluation process. Consideration is given to verifying doctrine, organization and tactics, basis of issue, logistical support, and training requirements. The UT is characterized by qualitative observations and judgments of selected military personnel who have a background of field experience with a type of materiel similar to that undergoing tests. Instrumentation is limited to measuring characteristics of major operational significance.

*Superscript numbers correspond to reference numbers in Appendix A.

c. Environmental tests are conducted to determine whether an item will perform effectively in the environments in which used. The most important policies and criteria regarding environmental testing of general supplies and equipment, including those in AR 70-38*, are:

(1) All Army equipment is required to perform effectively in the climatic design types described in AR 70-38. Other required climatic design types are delineated in requirements documents.

(2) Testing materiel in natural adverse environments, such as the arctic, desert, jungle, seashore, and mountains, is costly in terms of manpower, money, materiel, and time, and is normally a part of service testing. During TT, the maximum amount of testing is performed in climatic chambers that simulate the adverse environments.

(3) During early development phases, the design agency may conduct tests (EDT) to verify that certain components can perform adequately under the climatic extremes, or it may request that the tests be performed by the U.S. Army Test and Evaluation Command (TECOM). These data should be evaluated and accepted when valid in lieu of further testing.

(4) Upon receipt of the prototype for TT, all environmental tests required by the requirements documents are performed if they are within the capabilities of the environmental chambers and if they are economically feasible. Data from earlier testing will be used to reduce the scope of further testing, if the data are usable and no modifications have been made that will affect test results. Though the design agency may resort to overtests, it is the policy to confine testing to simulation of the conditions specified in AR 70-38 insofar as possible. Standard chamber testing of general supplies and equipment involves high and low temperatures, solar radiation, sand and dust, rain, freezing rain, high humidity, and salt spray. Improvised facilities are used in special cases such as measuring static electricity generated by certain clothing systems, or controlled flame tests to determine textile flammability resistance. For large items, salt water immersion and sea air exposure tests are conducted in conjunction with logistics-over-the-shore (LOTS) tests at Fort Story, Virginia. Fungus tests are performed for TECOM by the White Sands Missile Range and the U.S. Army Chemical Research, Development, and Engineering Center.

(5) In addition to potential economical advantages, chamber testing provides controlled extreme conditions that are desired but sometimes not achieved at climatic test sites. In conducting environmental tests, it must be remembered that AR 70-38 defines criteria and conditions, not test procedures. For test procedures, first choice will be those that are specially devised and described in TOPs/ITOPs; otherwise, MIL-STD-810D* is the document most used by the test activity. Both chamber testing and environmental testing are necessary. Developmental items should be chamber-tested before being tested in natural environments. The climatic test activities (Yuma Proving Ground, Cold Regions Test Center, and Tropic Test Center) prepare test plans for the field environmental tests conducted at the specialized sites.

(6) Environmental testing of general supplies and equipment under adverse conditions not related to weather includes: vibration, transportability,

off-road, rough handling, electromagnetic interference, and nuclear-biological-chemical (NBC) conditions.

d. Common subtests contain procedures which are, or can be, adapted to apply to two or more commodities or test items. Some of these, including common subtests not listed in TOP Volume 10, generally apply to all commodities in the category of general supplies and equipment, and include the following subtests:

(1) Endurance

(2) Human factors evaluation

(3) Logistic supportability

(4) Operator training and familiarization

(5) Physical characteristics

(6) Reliability

(7) Safety evaluation

(8) Transportability

(9) Value analysis

Other common subtests, applicable only to certain groups of specialized equipment, include the following:

(1) Air drop capability

(2) Assembly and disassembly

(3) Compatibility with related equipment

(4) Logistics-over-the-shore

(5) Line haul

(6) Cargo-loading adaptability

(7) Electrical power requirements

(8) Environmental tests

(9) Electromagnetic interference

(10) Food-acceptance surveys

3. <u>TEST PLANNING</u>.

a. The TOPs for planning tests of general supplies and equipment are included in, but not limited to, Volume 10. Subtests are selected from

pertinent TOPs/ITOPs to evaluate the test item in compliance with stated objectives, even though test data may be derived from other sources (e.g., EDT, field use). Test planning requires review of test guidance literature, familiarization with preceding development and test phases, study of test criteria, and selection of appropriate samples, methods, sequence of tests, facilities, and test equipment. Risk/cost and safety provisions must be given prime consideration. Data from previous and similar tests should be considered in order to avoid duplication and reduce the scope of further testing.

b. To write a test plan, first refer to the appropriate system TOP/ITOP for the item/system that is to be tested. This system TOP/ITOP in turn will list pertinent common TOPs/ITOPs and other documents suitable for testing the item (e.g., MIL-STD-810D). Write the test plan in accordance with TECR 70-24[6] and submit it to TECOM HQ for approval. Local guidance for writing test plans is contained in the Test Directors' Handbook (CM 70-17[7]).

4. SAFETY DURING TESTING. Safety is paramount in all DoD test operations. Task 204 of MIL-STD 882B[8] states: "...shall perform and document a system hazard analysis to identify hazards and assess the risk of the total system design..."

All tests shall therefore be reviewed to ensure that:

(a) A system safety hazard analysis shall be performed to ensure that pertinent safety specifications and criteria are verified and to identify unknown hazards or procedures which may have been designed into the system. TOP 1-1-060[9] shall be used as a guide for planning and conducting the subtest.

(b) The testing will be carried out in a safe manner.

(c) All additional hazards introduced by testing procedures, instrumentation, test hardware, etc., are properly identified and minimized.

U.S. Army Materiel Command (AMC) implements DoD and DA policy on safety during testing through AR 385-16[10] which establishes provisions for life cycle verification of materiel safety, and AMCR 385-100[11] which prescribes the general safety rules of AMC and AMC major subordinate commands. Local testing installations publish separate safety manuals and regulations to parallel the AMC publications with respect to their specific safety missions, range facilities, and testing sites. Within the overall scheme of development and testing, four documents are developed pertinent to safety:

a. Safety Assessment Report (SAR). This is a formal summary of the safety data collected during the design and development of the system. In the SAR, the materiel developer summarizes the hazard potential of the item/system, provides a risk assessment, and recommends procedures of other corrective actions to reduce these hazards to an acceptable level. The SAR must be provided to the TT agency before testing begins.

b. Standing Operating Procedure (SOP). AMCR 385-100 states: "...Before starting any operation involving ammunition, explosives, or other hazardous operation, an adequate standing operating procedure shall be developed and approved by the Commanding Officer of the activity or by a qualified member of the staff who has been delegated the responsibility for review of and authority

for approval of standing operating procedures....". Each test activity/proving ground maintains its own file of SOPs. Before conducting a test, the test director must be sure that an up-to-date SOP exists to ensure safety during the testing of a particular item. The test director will study all SOPs which pertain to the test/operation in which he/she will participate, and will follow all instructions contained in these SOPs. If an up-to-date SOP does not exist, the test director will immediately begin writing one, following the instructions contained in AMC Reg 700-107[12], w/TECOM supplement, and local TT agency SOP.

(1) Plan tests so as to permit minimum hazard (e.g., using dummy cargo instead of live ammunition, using simulants instead of toxic agents, and using diesel instead of more volatile fuels when possible) when test objectives can be met in that manner. Particular precautions are instituted for specific tests, such as fire-fighting and electrical grounding in POL-related tests, stand-by craft for marine tests, and medical surveillance for toxic-agent tests. Provisions of AMCR 385-100 apply to safety in all testing. Detailed plans shall include safety procedures, precautions, protection (including clothing and immunization), and emergency procedures (including evacuation and medical) as necessary.

(2) SOPs for hazardous operations are permanent documents which can be amended by changes or augmented by supplements. SOPs pertain to specific operations or tests of individual items/systems. By regulation, SOPs must be updated every 2 years.

c. Safety release. This is a formal document issued to a user test organization before any hands-on use or maintenance by troops. The safety release indicates that the item/system is safe for use and describes the specific hazards of the item/system, based on test results, inspections, and system safety analysis. Operational limits and precautions are included. The test agency uses the data to integrate safety in test controls and procedures, and to determine if test objectives can be met within these limits. A limited safety release is issued when further safety data are pending (e.g., completion of further testing or a certain safety test), and restricts a certain aspect of the test (in accordance with AR 385-16). AMC and HQ TECOM supplements to AR 385-16 provide more information about the issue and use of safety releases.

d. Safety confirmation letter. This is a separate document or part of the independent evaluation report (IER) or position letter that provides the materiel developer with the DT or UT agency safety findings and conclusions and states whether the specified safety requirements are met (in accordance with AR 385-16).

5. EXPERIMENTAL DESIGN. Commodity engineering, service, and environmental tests for general supplies and equipment are specifically designed to check the functioning of a specific item of equipment selected from this category. As part of such testing, each commodity item is subjected to individually tailored operations and performance subtests and selected common subtests as applicable. Each of these subtests consists of procedures or instructions for observing and recording the technical characteristics of a given commodity as determined or evaluated under simulated operational and environmental conditions.

a. Operations and performance subtests are often unique to the item being tested and are not contained in the common subtest documents. The subtest methodology and instrumentation techniques used are organized to provide data necessary to assess and determine the performance qualities of the test item as measured against the specific test criteria defined in the test directive, requirements documents or other governing documents. Test design is a sum of the information obtained from previous tests of similar types of equipment (if available) plus the applied knowledge and experience of the person writing the test procedure. Risk analysis techniques will be applied during the planning and conducting of all suitability tests.

6. INSTRUMENTATION TECHNIQUES. An essential step in testing general supplies and equipment is the development and acquisition of adequate test data to determine and assess the suitability of the individual commodity for service test or for Army use. To acquire the data, many state-of-the-art sampling devices should be used. Instrumentation techniques consist of assessing the test procedures and requirements stated in the test directive, requirements documents, and other governing documents and selecting the sampling devices that will best provide the data. All instrumentation used for data acquisition, repair, and maintenance shall be calibrated and certified before use.

7. STATISTICAL TECHNIQUES. The function of statistics is to separate, as far as possible, the truth from error by narrowing and defining the region of doubt. Note, however, that statistical study is concerned primarily with the precision of measurement. It cannot reveal anything that is not implicit in the data, and cannot remove systematic errors from a set of data. Accuracy is a matter of test methodology and equipment. The added precision afforded by statistical study may permit detection of a discrepancy, which is a necessary step. Because of the wide range of commodity types included in the testing of general supplies and equipment, the statistical techniques presented in this TOP are general in nature and must be fitted to each individual commodity test, as required.

a. General considerations in planning. It is advantageous for the test plan author and test director to consult with the statistical analyst before conducting the test to determine the experimental design setup. The proper design for the experiment will aid in controlling bias and in measurement precision, will simplify the necessary calculations of the analysis, and will permit clear estimation of the effects of the factors. Three statistical tools aid in developing the proper design for an experiment. These are discussed in the following paragraphs.

(1) An important class of experimental design is characterized by planned grouping. The tool of planned grouping can be used to take advantage of naturally homogeneous groupings in materials, machines, time, etc., to take account of "background" variables which are not direct factors in the experiment.

(2) Randomization is an arrangement of tests, samples, and other factors to simulate a chance distribution, reduce interference by irrelevant variables, and yield unbiased statistical data. It is a statistical tool which ensures valid estimates of experimental error and makes possible the application of statistical tests of significance and the construction of confidence intervals.

(3) Replication is the repetition of an experiment or procedure at the same time and place. Where a measure of precision must be obtained from the experiment, replication provides this measure. In addition, it provides an opportunity for the effects of uncontrolled factors to balance out and thus aids randomization as a bias-decreasing tool.

b. Measurement of data. Measurements cannot be made with complete accuracy of precision. The terms "accuracy" and "precision" denote two different ideas which are inherent in the measurement method. Accuracy of a measurement method refers to the ability of the method to provide a reading which conforms to the true value, whereas precision of a measurement method refers to the ability of the method to provide repeated readings which to a degree are in sharp agreement with each other regardless of whether they represent the true value. If a magnitude is to be determined with accuracy to a required percentage, it is necessary that the test method and equipment have precision of this order; that is, precision is a prerequisite to accuracy, but precision does not guarantee accuracy. In general, the test objective will determine the requirements for accuracy and precision, and these in turn will determine the test methods and equipment to be used. The measured value of a characteristic may be represented by the following relationship:

MEASURED VALUE = TRUE VALUE + ERROR VALUE.

c. Sources of errors. A review of the subject of error sources is an important step in understanding the error value and finding ways to reduce it, and as a means of estimating the validity of the final report. Errors may originate in a variety of ways and may be categorized as gross errors, systematic errors, and random errors.

(1) Gross errors include mistakes made in reading and recording data. The responsibility usually lies with the test personnel for slips such as the gross misreading of a scale or transposing figures when recording the result. Errors of this type may be of any amount and are not subject to mathematical treatment. Two things can be done to avoid such difficulties: exercise care in reading and recording the data; make two or more determinations of the desired quantity, preferably at different reading points to avoid re-reading with the same error. Then, if the readings show disagreement by an unreasonably large amount, the situation can be investigated and the bad reading eliminated.

(2) Systematic errors may be further subdivided into instrumental errors, personnel errors, environmental errors, and observational errors.

(a) Instrumental errors are due to shortcomings of the instrument. All instruments and standards possess inaccuracies of some amount. As supplied by the maker, a tolerance allowance is always present in the calibration, and additional inaccuracies may develop with use and age. As an example, suppose that measurements of length are made with a yardstick after a small amount has been cut from the zero end; all measurements made with this yardstick will be systematically in error by a constant amount. Or, as another example, the ratio arms of a Wheatstone bridge may have an actual ratio different from the marked value. This causes a systematic instrumental error of a proportional amount for all measurements using these arms. An indicating instrument, such as a volt-meter, has scale errors. These errors are generally different at different parts of the scale, do not partake of either the

constant or proportional type, and must be expressed by a correction curve. It is important to recognize the possibility of such errors when making precision measurements, for it is often possible to eliminate them, or at least to reduce them greatly by careful planning of procedure, application of correction factors, and careful recalibration of the instruments.

(b) Personnel errors are systematic errors caused by misuse or improper loading of the instruments. A good instrument used in an unintelligent way may give poor results. Measurement shortcomings can be traced, for example, to failure to make a needed zero adjustment in a bridge or meter, poor initial adjustment, or the use of connecting leads of too high resistance for the measurement being made. Careless or uninformed use of an instrument may also cause permanent damage as a result of overloading and overheating. In this case, the value of the instrument, and of future as well as present readings, is depreciated until the trouble is detected and repairs are made. Indicating instruments always change to some extent when connected into a complete circuit; sometimes the effect is negligibly small. Sometimes the effect, though not negligible, can be corrected by computation. At other times, the presence of the instrument produces so great a change in the circuit that operating conditions in the circuit are altered radically. Test personnel must take into consideration the effect that the measuring equipment has on the circuit, and plan the measurements accordingly.

(c) Environmental errors are also called "errors due to external conditions," i.e., conditions external to the measuring device. This includes any condition in the region surrounding the test area that has an effect on the measurements. One common source of variation comes from temperature changes of the equipment. Some instruments may be affected by humidity, barometric pressure, the earth's magnetic field, gravity, stray electric and magnetic fields, or other environmental conditions. Actions that can be taken to eliminate or at least reduce undesirable disturbances consist of maintaining environmental conditions as nearly constant as possible, using equipment immune to environmental effects, and applying correction factors. It should be noted that any of these methods can be considered, at best, to neutralize the major part, but not all of the error. Correction is accomplished to a "first order" of approximation, but leaves "second order" or "random" errors.

(d) Observational errors or "errors of the observer" is a term that recognizes that a "personnel equation" exists for the observer, so that people using the same equipment for duplicate sets of measurements do not necessarily produce duplicate results. One observer may tend characteristically to read a meter higher (or lower) than the correct value, possibly because of his reading angle and failure to eliminate parallax. Important readings which may be subject to this type of error should be shared by two or more personnel to minimize the possibility of constant bias.

(3) Random errors occur in a manner that their time of occurrence is unpredictable, and may be characterized, for example, by an exponential distribution. To reduce such errors, it is necessary to reduce the time exposure (shorten the mission) or to redesign to reduce their probability of occurrence. Corrective action usually is not within the province of the test planner.

8. DATA REDUCTION.

a. Analysis of data. A large amount of data is collected as a result of testing. Because these data have meaning only in comparison with similar data, the quantitative measures obtained from a test must be reduced to values having units which are acceptable as a basis for comparison. In reducing the data, errors which would affect the accuracy of the results must be identified and compensated for. When raw data have been reduced to workable numbers, the statistician, using proven mathematical methods, arrives at a conclusion. The conclusion may be a statement that a population parameter falls within an interval accompanied by a statement of assurance given in percent.

b. Presentation of data. The final step is the presentation of data. It must involve thought and intelligence in its preparation, and is influenced by the capability, the ingenuity, and background of the analyst. The test of good data presentation lies in its usefulness to equipment performance analysts who evaluate the data relative to established criteria and make the recommendations regarding acceptability of equipment performance.

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APPENDIX A

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